Automatic Volume or Sensitivity Controls

LESSON ND-25

SPRAYBERRY ACADEMY of RADIO

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PUEBLO, COLORADO

Automatic Volume or Sensitivity Controls

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In the previous lessons of your SAR course, you have studied the basic details of conventional radio circuits. You are now ready to study the various improvements, refinements and modifications of these circuits which have been adopted to improve, ease or otherwise enhance the art of radio reception.

It is these various refinements which bring about endless changes in both transmitting and receiving circuits. They furnish material for countless magazine articles and for each radio manufacturer to both mechanically and electrically improve his product. In the past few years, there have been improvements in every part of every common circuit in receivers. There have been many improvements in antenna design, RF circuits, oscillators, IF circuits, audio amplifiers, speakers, tubes and many improved tuning devices to assist the operator of the receiver in tuning in signals correctly.

The succeeding lessons will cover some very definite and individual refinements used in present-day design. This lesson begins the series of refinements with one which is, perhaps, the most important of all of them—Automatic Volume Control.

It was not through inadequate control of volume or lack of ability of the operator to properly adjust output volume level that a need for this improvement arose. Rather, it was the convenience in tuning from one station to another and to compensate for fading that Automatic Volume Control (AVC) was devised. The automatic control of the *gain of a receiver* in an *inverse proportion to the strength of the signal* is a great advantage. The basic principle of all AVC systems is based on this control of amplifying gain. *A portion of the received and amplified signal is rectified, filtered to ripple free DC and applied to one or more amplifier tubes as a grid bias voltage.* As you proceed with this study, you will realize that the conventional AVC is actually a method of varying the *sensitivity* of the receiver *more than it is a volume control.* Thus, the *weaker* the received signal, the more sensitive is the receiver. There are three main systems of AVC. Each succeeding system is the result of engineering improvements on the preceding system. For a particular purpose, one may be more suitable than the others. These AVC systems will be described in the order of their development — first, *ordinary AVC,* second *delayed AVC* and third, *quiet AVC.* The abbreviations for these three systems are AVC, DAVC and QAVC.

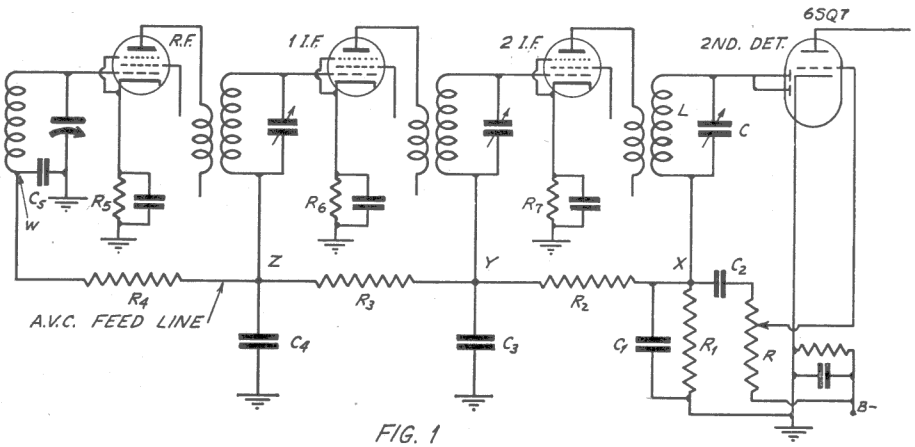


FIG. 1

In order that you may understand just what AVC is supposed to accomplish, refer to Fig. 1. This circuit will be thoroughly explained later on in this lesson. For the time being assume that the 2nd detector diode tube develops a rectified voltage across R1 in Fig. 1. As will be explained later, the rectified voltage across R1 is considered the AVC source voltage. When conditions are right this voltage is applied along the circuit of R2, R3 and R4 to the control grids of the IF and RF tubes. *The polarity of the AVC voltage is such that it adds to the normal grid bias for the RF and IF tubes.* These tubes are of the variable-mu or super control type and will, therefore, take or accept a wide range of grid bias voltages without cross modulation taking place. Resistor R5 furnishes normal grid bias for the RF tube while resistors R6 and R7 furnish normal grid bias for the IF tubes. With no signal being received these normal values of grid bias hold the plate currents of the tubes to normal rated values. When signals are received the AVC voltage comes into being across R1 in Fig. 1 and adds to the normal bias of the tubes. This decreases their mutual conductance, and thus their amplifying ability is reduced. The stronger the received signal, the greater becomes the AVC voltage and the more the amplifying ability of the tubes is reduced. In this way, an even and automatic control of volume is attained (within limits). Thus the receiver operator does not have to be continually changing the manual volume control by hand for varying input signal strengths. Just how all of this is accomplished will be explained in the remaining portion of this lesson.

To refresh your memory on principles which have already been studied, refer to the simple rectifier circuits shown in Figs. 2 and 3. In Fig. 2 there is a 100 volt battery connected in series with a diode tube rectifier and resistor R. The battery is a voltage source, the diode is a half-wave rectifier and the resistor R is the load. The correct polarity is indicated for the diode load circuit. Note that current flows through the entire

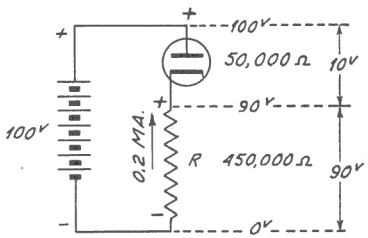


FIG. 2

circuit. With 100 volts impressed between the plate and cathode of the diode, assume it will pass .2 milliampere of current which means it will have an internal DC resistance of 50,000 ohms. Together with the 450,000 ohm external load, the total resistance of the circuit will be 500,000 ohms. Note in this case there is a 90 volt drop across the load resistance R,

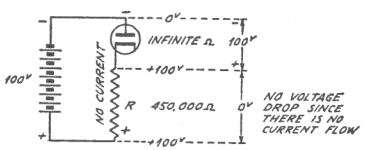


FIG. 3

and that the end next to the cathode is positive with respect to the other end.

Now if the battery is reversed, as in Fig. 3, no current can flow through the tube as the plate is now made negative with respect to the cathode. Hence, it repels electrons emitted by the cathode. If the battery of Figs 2 and 3 is replaced with an AC source, as in Fig 4, you will realize that current will flow when the polarity of the AC source makes the plate positive with respect to the cathode, and no current will flow when the

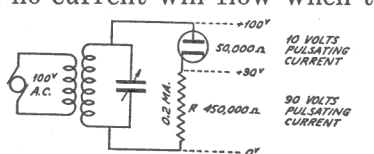


FIG. 4

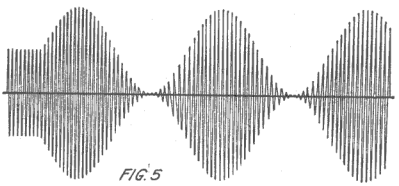


FIG. 5

polarity is reversed, as in Fig. 3. In the case of Fig. 4, the AC source could easily be the *amplified intermediate frequency* (IF) or radio frequency (RF) which carries the modulation of the received signal. The nature of this RF or IF source voltage is graphically represented in Fig. 5. When rectified, the current flow will occur in AF pulses, as represented in Fig. 6. This, as you know, conforms to detector principles which you have already studied.

In connection with the received signal, the principal function of the detector as in Fig. 4 is to collect all of the RF energy by filtering and making use of its relatively gradual changes in intensity which, of course, varies as the audio frequency or signal voltages varies. The usual detector circuit makes no use of the direct current which is inevitably formed through rectification. The AC signal voltage is usually removed from the detector system by means of a coupling condenser—thus passing it on to the next AF stage. In a receiver which employs AVC, the DC which is a result of detector or rectifying action is not allowed to waste or serve no useful purpose. Instead, the detector circuit is arranged to make use of the

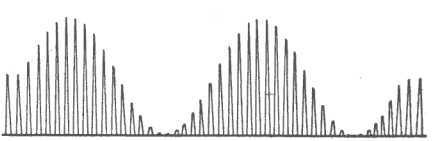


FIG 6

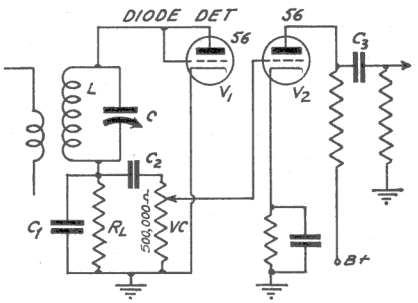


FIG. 7

DC as an AVC controlling voltage.

A typical detector system which makes no use of the DC is shown in Fig. 7. The load resistor, R_L, is by-passed with C_1 so that the IF pulses will be accumulated together as an average voltage varying with the modulation. Condenser C_2 couples the normal volume control resistor (VC) to the diode circuit, eliminating the direct current from the AF system but transferring all audio variations (AF) to the grid of the AF tube. Note that a triode is wired as a diode in Fig. 7 to provide diode detector action. A similar triode tube, and in this case wired as a triode, is used as the AF tube.

In AVC circuits, practical use is made of the DC *produced by the diode.* Without changing materially the operation of the circuit as a detector, use is made of the DC as well as the audio signal simply by employing the proper filter system.

Obviously, it is impractical to connect a *low value reactance* across any circuit carrying the audio frequency as this will cause it to be filtered out or reduced in intensity. *Since it is not necessary in an AVC system to draw any current from the diode circuit, the problem is greatly simplified.* The reason why little or no current is drawn by the AVC system from the detector circuit and other related details will be explained later on in this lesson.

As it is not proposed to draw any current, a resistance high in value may be used as a medium through which to apply the pulsating DC voltges which are taken from the diode circuit. Thus good filter action is obtained in conjunction with a suitable condenser. Therefore, consider the use of a 2 megohm resistor for this purpose, as in Fig. 8. The actual voltage at point X in Fig. 8 with respect to ground is a negative DC voltage, representing the rectified signal voltage. Graphically, it may be represented in a manner similar to the wave form shown in Fig. 9. The current can only flow in one direction, being pulsating DC. In Fig. 8, it flows towards ground through resistor R_L from the diode plates. *If the received carrier wave is unmodulated* (no signal imposed on the carrier) *the voltage at point X may be represented as in Fig. 10.* Note this carefully—the volt-

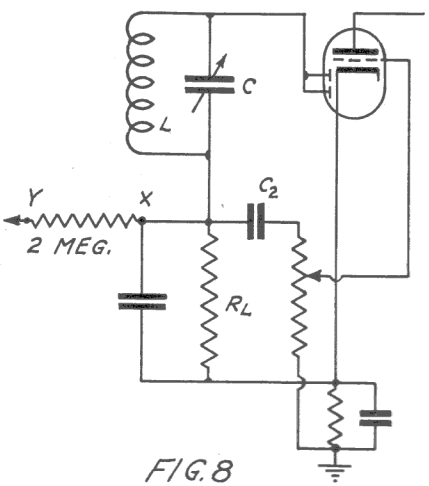


FIG. 8

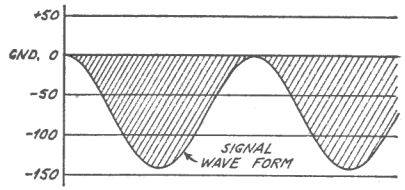


FIG. 9

age at point X in Fig 8 is proportional to the average carrier energy or voltage *and not proportional to the signal or modulation.* For example, if the IF carrier is amplified until its value is 100 volts R. M. S. across the final tuned circuit, a DC voltage of approximately 100 volts will be developed across the load resistor R_L *regardless of the nature or amount of modulation.* This observation would be true for all AVC systems in general.

At the remote end (Y) of the 2 megohm resistor in Fig. 8 there is a voltage with exactly the same value as at X because no current is flowing through it. A sensitive meter connected from point Y to ground would prove this to be true. If the remote end (Y) of this resistor is by-passed to ground with a large condenser, there will be a practically pure DC at Y which will be *almost exactly proportional* to the carrier voltage (unmodulated carrier). The introduction of a filter condenser will cause a small current to flow through the 2 megohm resistor. However, it will only be that

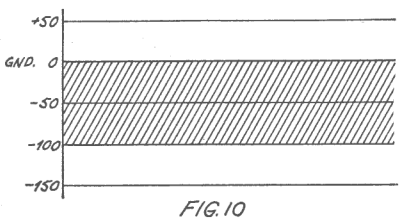


FIG. 10

amount required to charge and discharge the condenser. Hence, with this one qualification, an AVC system will have no flow of DC through it. A suitable filter condenser for an AVC system is shown in Fig. 11 as C_3.

In arriving at a value for the 2 megohm resistor and for the .5 mfd. condenser in Fig. 11, it is necessary to see what effect these values have on the *effective filtering* of the RF variations of voltage occurring at point X.

Inasmuch as a resistance has no reactive effect and cannot smooth out the current, by virtue of this fact it is necessary to depend en-

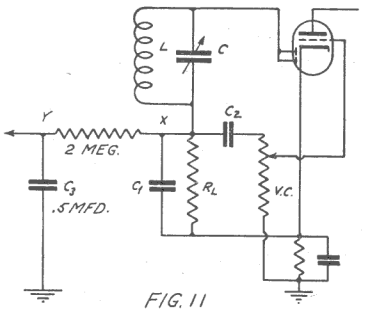


FIG. 11

tirely upon the charging and discharging time of the condenser and resistor in order to smooth out the RF variations. This, in turn, depends on the product of RC—the resistance through which the voltage is impressed—and the value of the filter condenser C_3 (Fig. 11). You may ask why are not C_1, R_L, C_2 and VC involved in this discussion as they are connected to X just as much as the 2 megohm resistor. The answer is that they are, indeed, factors and that their values must conform to certain laws also. For example, if you consider point Y a voltage source feeding point X, the filter-

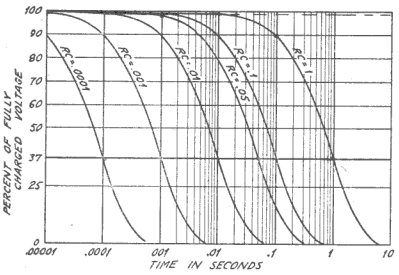


FIG. 12

ing effect of the resistor and condenser C_1 would determine definitely the values to use. If the value of the resistor and condenser are so chosen that their discharge time will be in unison with the RF variations to be expected at point X in Fig. 11, then most or all of the RF ripple will be removed leaving only a pure filtered DC to act on the rest of the circuit.

A chart has been prepared in Fig. 12 showing various values of the product RC (R times C) and their dependence on the time of discharge. The information in it cannot be grasped at a glance, so you must think out each of these values to get the proper information from the chart.

In the first place, a logarithmic separation of time units has been used which might be misleading if you do not consider them carefully. Originally basic or fundamental electrical units were used for RC, but you will find that using R in megohms and C in mfd. will give the same results.

By selecting values of 2 megohms and .5 mfd., the product RC, of course, is $2 \times .5 = 1$ second. One of the curves in Fig. 12 is labeled RC=1. Interpretation of the curve is as follows:

If the voltage at X, Fig. 11, rises up to 100 volts and drops to zero in .01 second, the voltage of C_3 will have dropped only to 99 volts or 1%. This value is arrived at by tracing up the .01 second vertical line to where it crosses the RC=1 curve. In one-tenth second (trace up the .1 second vertical line) it will have dropped only 10% from its original value of 100 volts. At the end of one second (trace up the 1 second vertical line), it will have dropped 63% or down to 37% of its original value. Check this by referring to the graph of Fig. 12. With an IF of 460 KC, the voltage at X of Fig. 11 will be at maximum (100 volts, in this case) 460,000 times a second and will drop to zero in one-half the time required for 1 cycle or 920,000 times per second or in approximately .000001 second. For the RC=1 curve in Fig. 12, note that the smallest time shown on the graph is 10 times this value (.000001 second) or .00001. At this time value the voltage has dropped to approximately .00001 volt or to .001% from its maximum value. This is a calculated value as a value as low as .000001 volt cannot be read from Fig. 12. Thus, the 100 *volt ripple* is filtered out to a value less than 10 microvolts at C_3 of Fig 11. A 10 microvolt value is equal to .00001 volts. Thus, the use of a 2 megohm resistor and a condenser of .5 mfd. reduces a 460 KC IF ripple to practically a ripple free DC for use as an AVC voltage.

A value is assumed for the foregoing example of a ripple of 100 volts whereas the presence of C_1 in Fig. 11 will eliminate all but about 1% of this ripple before it starts to affect the 2 megohm resistor and the capacity of C_3.

With lesser values of RC (2 megohms and .5 mfd), by reducing the resistance of R or the capacity C, *the time of discharge is made even shorter.* For example, if R were 100,000 ohms and C .1 mfd., RC would equal .01. See the RC=.01 curve in Fig 12. This combination would probably serve the same purpose as it would filter the 1 volt ripple to .1% in .00001 second so that there would still be virtually pure DC at the Y terminal in Fig. 11.

It has been shown how a resistor and capacity circuit are used to obtain a pure DC from a modulated rectified IF carrier. In addition to this, the circuit just mentioned must filter out the *audio component* because when the carrier is driven to zero voltage, there is, for an instant, no energy in the circuit. The lowest frequency which need be dealt with is about 50 cycles, and a 50 cycle peak requires .01 second to reduce to zero. Therefore, according to the point where the .01 second vertical line crosses the RC=1 curve in Fig. 12, the filtering will be 99% effective (estimated from the graph). Values of time constant below RC=1 should be used to keep the audio filtering better than 90% effective.

VALUES OF THE FILTERED DC VOLTAGE

The DC voltage which is available for AVC control is directly proportional to the carrier strength of the IF output of the receiver. *Due to half-wave rectification, it is somewhat below the R.M.S. value.* Depending upon the efficiency of the rectifier (detector), it ranges from 55% to 70% of the carrier peak value. *In any one receiver, this percentage remains the same.* It might be suggested that the carrier energy or average peak voltage depends upon the frequency of modulation which, of course, is granted. However, once the percentage has been acquired, it remains prectically constant. The effect of these variations will be discussed further on in this lesson. In any event, the DC produced for AVC is proportional to the average carrier intensity. To be used as a control of bias voltage, it only requires filtering and the use of the necessary voltage divider to provide the proper relative values of control voltage.

MANNER OF AMPLIFICATION CONTROL

In connection with AVC, the super control tubes of both the tetrode and pentode types have their greatest utility. In a former lesson you learned of the gradual effect of the grid voltage on the plate current in these tube types. Also, you learned how the slope of the Eg-Ip curve gradually reduced as the bias was increased, making the tube amplify less and less.

A good understanding of this effect can be had by referring to Fig. 13 which may use a 6K7 or 6S7G in a standard IF amplifier. In this circuit the normal bias is supplied by a cathode resistor, R, and an additional bias is supplied from the voltage drop across a potentiometer, R_1. The latter is placed across a 50 volt battery with its positive terminal grounded. The value of resistor R has been so chosen that when R_1 has its mova-

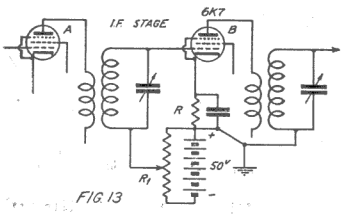


FIG 13

ble terminal on the positive end, the proper bias of 3 volts negative will be applied to the control grid. With this arrangement, the gain of the tube is maximum as its sensitivity is highest when 3 volts negative is applied to its grid. For example, assume that the gain of the IF stage is 100 for this condition, which it might well be for this type of tube. As the movable element of R_1 is moved down toward its negative end, the grid becomes gradually more negative, and the gain is reduced accordingly. This must be so because R_1 is in series with R and both are connected between the grid and cathode of the tube. Thus the voltage between grid and cathode is variable from 3 volts negative to 53 volts negative. At approximately 50 volts negative, the plate current will stop flowing and the tube will be completely blocked. The gain will, of course, reduce to zero at this time. From this you should understand that the gain of the tube in Fig. 13 can be varied from maximum to minimum by varying R_1. This could be a mechanically controlled way of obtaining variable sensitivity. This, however, would not be practical because the action is not automatic. When automatic action is obtained AVC is accomplished.

All that remains now to show complete AVC action is to detach the battery and potentiometer of Fig. 13 and connect the point Y of Fig. 11 to the grid return of Fig. 13—thus making the circuit appear as in Fig. 14.

Values are assumed in Fig. 14 based on practical circuits of this type. Figure 14 shows an IF stage feeding into a diode-triode second detector tube with AVC. The IF tube is controlled by the AVC voltage. In the first column of the accompanying table are given various AVC voltages as produced by the diode from the average carrier value. This is added to 3 volts in the second column of the table, the former being the minimum bias provided by the cathode resistor. In the third column, the probable gain of the stage at these various total bias voltages is given. Assume that a signal is fed into the grid circuit of the IF tube, as in Fig. 14, having a value as listed in column four. With the listed input signal and a gain corresponding to the proper place in the table, an output voltage across R_L of Fig. 14 as in column five will be obtained. In the table it has been assumed that 60% of the value in column 5 is the AVC voltage produced which appears in column one. Column six of the table shows the output voltage which would result if no AVC were used.

Now for a few examples based

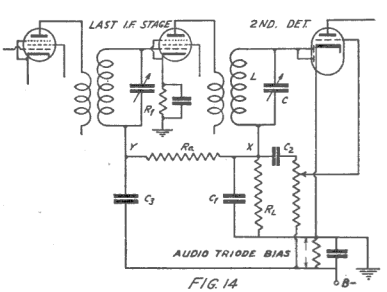


FIG. 14

1 AVC	2 Total Bias	3 Gain-Times	4 AC Input of IF	5 Output with AVC	6 Output without AVC
0	3	100	0	0	0
.5	3.5	99.8	.00834	.833	.834
1	4	99.5	.0167	1.67	1.67
1.5	4.5	99	.02514	2.5	2.51
2	5	98	.034	3.33	3.4
3	6	97	.0505	5	5.05
6	9	94	.1064	10	10.64
9	12	91	.165	15	16.5
12	15	87	.23	20	23
15	18	82	.305	25	30.0
18	21	75	.40	30	40
21	24	66	.53	35	53
24	27	55	.727	40	72.7
27	30	42	1.071	45	Over-
30	33	31	1.612	50	load
33	36	22	2.50	55	"
36	39	15	4.0	60	"
39	42	10	6.50	65	"
42	45	6	11.65	70	"
45	48	3	25.00	75	"
48	51	1	80.00	80	"

NOTE: All of the above figures represent volts with the exception of the GAIN-TIMES column.

on the table. Assume for Fig. 14 there is an IF input signal of .4 volt at the grid of the first IF tube. Ordinarily this would be amplified 100 times as this is the normal gain of the stage. This, in turn, would produce 40 volts output as indicated in column 6 of the table. However, this 40 volts, when impressed in the form of half-wave rectified IF across R_L will result in an AVC voltage of 60% of 40 volts or 40× .6=24 volts. Added to this value is the 3 volt minimum bias (produced by R_1) which gives a total of 27 volts. At this new value, the gain of the tube is reduced to 55 as indicated in the table. You will find that a signal of .4 amplified 55 times instead of 100 will give a total across R_L of only 22 volts—60% of which is 22×.6=13.2 volts for AVC. Added to 3 volts this will give 16.2 as a total bias. Referring to the table again, it is found that at this new bias, the gain of the tube has reached about 85 (between 82 for a bias of 18 volts and 87 for a bias of 15 volts). This, in turn, will result in amplifying the original signal more, producing more bias, *until a stable point is reached* when the bias cannot increase further for the input signal voltage in question. For a .4 volt signal, this value is 18 volts, the gain at this voltage is 75, the total bias is 21 volts and the output is 30 volts with AVC. Sixty percent of this 30 volts produces

exactly 18 volts, *and the circuit voltage remains stable at this value.*

It is important in this study to note that, as the input signal voltage increases, the output signal voltage increases. However, with AVC, the rate of increase of output for a given input increase is somewhat less than without it. For example, the output *without AVC* is exactly proportional to the input as .00834×100=.834; .165×100=16.5, etc. With AVC this is not true as the output to input ratio diminishes from 100 to 1 as the bias is increased. It should also be obvious that no input signal can exceed this ratio of 100 to 1 because beyond this point the tube is actually attenuating or reducing the amplitude supplied to its grid, and it is apparent that if the output is successfully reduced, it cannot supply an increasing bias. A stable bias value which will remain substantially constant as long as the receiver is tuned to a particular station is produced to within 1/10th to 1/20th of a second. As this bias is being built up by the signal, its effect is immediately impressed on the preceding tube or tubes, and this action cuts down the signal producing it. Hence, the value of AVC as an automatic sensitivity control.

If the signal input is plotted in graph form with both outputs, one with AVC and the other without AVC, two curves will be obtained as in Fig. 15. Here the signal is measured on a log scale so that a large ratio of values may be shown. Note from Fig. 15 that there is always *less output with AVC* than without it although for low signal strengths they are more nearly alike.

Without AVC, the maximum signal input to the last IF grid in Fig. 14 would be the overload limit of the AF system. Any increase above this limit would overload the audio system and cause severe distortion. With AVC the signal input may raise to 80 volts before overload occurs. It will remain at this value as no signal greater than 80 volts could possibly reach the second detector. In so doing, it would necessarily have to produce a cut-off AVC voltage to the grids of the controlled tubes. This, of course, is hypothetical as the last IF tube would be overloaded before this amount of voltage could be applied.

From the foregoing you may easily see that for the purpose of modern radio, this amount of AVC controlling *one tube only* would not be satisfactory. There must be more complete control, and it must act over a much greater range.

Since the grid being controlled does not draw current from the AVC supply, this same voltage may be applied to two, three or even more grids if necessary. For example, with three grids under control, as in Fig. 1, an analysis of the AVC action may be made as follows. Certain additions have been made in the circuit of Fig. 1 over that of Fig. 14 in order to provide control over the two additional tubes.

At point Y in Fig. 1 is connected a resistor, R_3, leading to point Z which is by-passed by C_4. If there is any possibility of a signal voltage drop across C_3 due to the

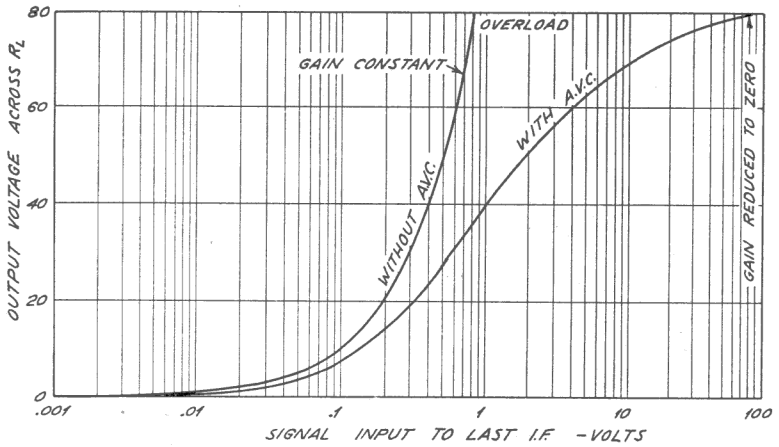


FIG. 15

regular amplifying action of the second IF tube, it will not be fed back to the first tube because of the filtering action of C_3. A 1 microvolt drop across C_3 might be as large as the signal on the first grid, and, if in phase, it would cause regeneration. If out of phase, it would cause neutralization. Both R_3 and R_4 are not absolutely necessary but are used to insure stability of the RF and IF amplifiers. As you have learned in a previous lesson, these resistors (R_3R_4) are called *decoupling* resistors and prevent feed back between stages of amplification.

Note in Fig. 1 that in order to supply the RF grid with an AVC voltage, the lower end of the grid coil must not connect to ground. The resonant circuit must be completed with a large value condenser C_5 which provides a short RF path to the cathode of the tube. The condenser C_5 serves the double function of forming part of the tuned circuit and filtering out any voltage variation of the AVC which may be fed to it.

As progress is made in Fig. 1 from the second detector to the left along the AVC *feed line,* there is increasingly greater need for filtering the AVC voltage. Also, there are more filter sections added for circuits of greater sensitivity. Thus, R_2 and C_3 form one filter, R_3 and C_4 form another and R_4 and C_5 still another. Due to the charging and discharging action of the condensers a small current will be drawn through R_2, R_3 and R_4. However this will not be large enough to place an appreciable load on the detector circuit.

For simplicity, assume in Fig. 1 that all three of the controlled stages have a gain of 58.5 each or a total gain of $58.5\times58.5\times58.5=$ 200,000. Also, assume that a 6SQ7 type tube is used for the second detector which may carry an audio signal of 2 volts peak. Thus, in Fig. 1, the AF must not exceed a peak voltage of 2 volts from X to ground with the *manual volume control R at maximum.* It is, of course, assumed that with a 2 volt peak signal the output of the speaker will be maximum due to AF amplification. When the sig-

nal rectified by the diode produces more than 2 volts from X to ground, the manual volume control R must be set to a point below its maximum position in order to avoid distortion.

The IF carrier peak voltage, of course, may be very much greater than 2 volts and still produce only 2 volts peak audio signal. A comparison of carrier and audio peaks is shown in Fig. 16. Allowing for lower than 100 percent modulation and filtering losses, the audio signal may be 2 volts with the rectified carrier peak at 10 volts or more. There is a very important point to remember in connection with this phase of the study. Usually the audio peak is within 30% to 40% of the carrier peak, due to high percentage of modulation and general effectiveness of the detector circuit.

This would mean that if as high as 50 volts IF peak were produced between X and ground in Fig. 1 for the purpose of AVC, there would be from 30% to 40% of this impressed across the manual volume control R. Thus, there would be from 15 to 20 volts impressed on the following grid which could not handle more than 2 volts at maximum. The volume control resistor R in Fig. 1 and in similar circuits is designed especially for this condition. It has what is known as a *left-hand taper* (manual volume controls are described

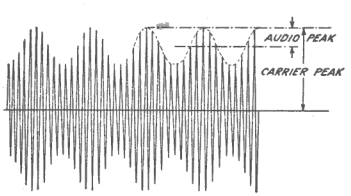


FIG. 16

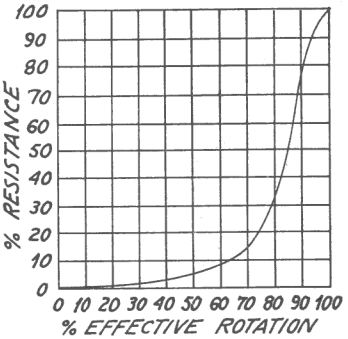


FIG. 17

in detail in your Service Course lessons), and its resistance is so proportioned that when the volume control is turned on *half-way*, only 5% of the full voltage across it is used. Thus, if a total value of 15 volts is assumed, only 5% of 15 volts or .75 volt will be delivered to to 6SQ7 tube in Fig. 1. It must be turned to about 65% maximum to pick up 2 volts when the total signal is 15 volts. Beyond this point, the signal advances rapidly. Below the half-way point, the resistance of the manual volume control R is very low, requiring a large rotation for a change in volume. In graphical form, this effect will appear as in Fig. 17.

You are, perhaps, wondering why the subject of manual volume control has been brought out in this study of automatic volume control. You will see, however, that the two are necessarily closely related and that it is of vital importance to consider both in evaluating a complete receiving system.

Assume in Fig. 1 that a voltage of 50 volts DC can be obtained from point X to ground in spite of the audio signal peak being only 2 volts from the volume control

Output Volts	AVC Volts	Total Bias	1 Stage Gain	Total Gain	Input	
0	0	− 3	58.5	200,000	0	Microvolts
.83	.5	− 3.5	58	195,000	4.275	"
1.66	1	− 4	57.4	189,000	8.7	"
2.5	1.5	− 4.5	57.2	186,000	13.44	"
3.33	2	− 5	55.2	168,000	19.8	"
5	3	− 6	53	149,000	33.55	"
10	6	− 9	50	125,000	80.00	"
15	9	−12	46	97,500	153.8	"
20	12	−15	41	69,000	290.0	"
25	15	−18	24	43,000	581	"
30	18	−21	27	19,683	1.524	Millivolts
35	21	−24	21	9,300	3.76	"
40	24	−27	16	4,096	9.76	"
45	27	−30	12	1,728	26.05	"
50	30	−33	9	729	68.6	"
55	33	−36	7	343	160.3	"
60	36	−39	5	125	480	"
65	39	−42	3	27	2.406	Volts
70	42	−45	2	8	8.74	"
75	45	−48	1	1	75	"

moving element to ground. Also assume that the stages which are indicated as being under automatic control contribute all of the gain to the receiver and that the total of this is 200,000. You may further assume, for simplicity, that this gain will be shared equally among the three amplifiers, making each one have a gain of 58.5, as this is approximately the cube root of 200,000.

The AVC will now affect the gain of each tube similarly and the total gain will be reduced by the cube of the reduction of one tube. It is important, therefore, to not only consider the gain per stage but the total gain of all of the stages which are AVC controlled.

Again it is necessary to study various selected voltages of the amplifier and their effect on the input sensitivity gain, etc. According to the accompanying table, an output signal voltage of 10 volts will produce 6 volts DC (60% of 10). This added to the normal bias already existing of 3 volts will give 9 volts bias on each tube. The gain per stage with 9 volts bias will be 50 and the total gain will be $50 \times 50 \times 50$ or 125,000. *Now to produce* 10 volts output from an amplifier having this gain, there must be introduced an input signal of $\frac{10}{125,000}$ or .00008 volts or 80 microvolts. If this output is tripled to 30 volts, it will give a bias of 21 volts total. Each stage, in this case, will have a gain of 27, making a total of 19,683. If the signal is 30 volts when fully amplified 19,683 times, it must have an input value of $\frac{30}{19,683}$ or .001524 volts. It is

important here to note that increasing the signal from 80 to 1524 microvolts, or slightly more than 19 times, has increased the output only 3 time (10 volts to 30 volts).

It should be noted also that the output cannot remain absolutely constant for various input values as one output is only capable of producing one AVC voltage and holding the gain of the receiver at one value. However, AVC will allow the input signal to increase much more rapidly than the output. When the output is only .83 volts, as you will see from the table, an input signal of only 4.275 microvolts is received. With the manual volume control *full on* a signal of 40% of .83 or .332 volt will result at the first audio grid which will give a substantial output to the speaker.

In a table of this kind, these figures do not have their full relative significance. A graph has, therefore, been made in Fig. 18 with the relative values of input signal and output signal level so that the effect of AVC will be more evident.

Upon examination, you will find from the table that the last tube in the system has a minimum bias of −3 volts at which it has the greatest gain and, therefore, cannot be supplied with more than 3 volts signal before overloading. This places a limitation on the signal received at the antenna of 8,775 microvolts because this input voltage will produce 3 volts at the grid of the last tube after having been amplified 3,418 times by two stages with gains of 58.5 each. *With AVC the input may be up to 3 volts before an overload occurs.* Higher input signals are shown in the table *for study only* as you would not expect to find signals larger than .5 volt at the antenna or input of the receiver.

As for the stages between the antenna and IF output with AVC, a much greater signal can be employed because as the gain is reduced with a subsequent bias increase, the signal peak may be as

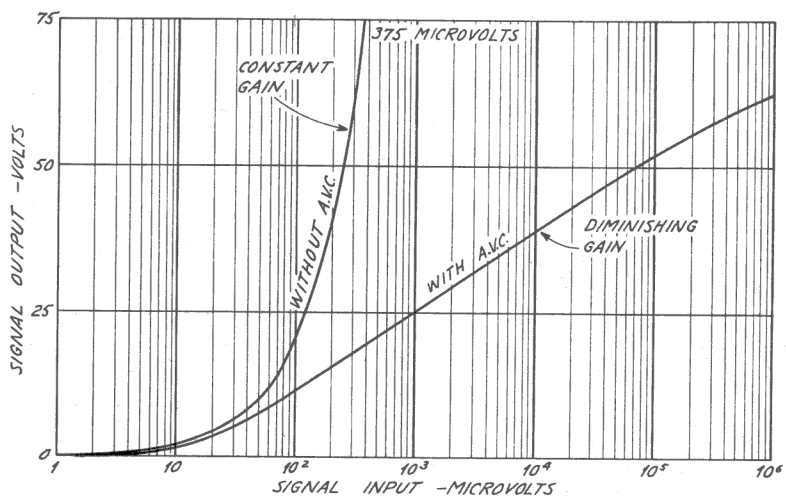


FIG. 18

great as the bias value for any tube as far as the grid action is concerned.

For example, suppose there is an output of 35 volts from the foregoing table producing −24 volts total bias. The gain of each tube will be 21. Now if the signal was as high as 24 volts, the plate voltage with this gain would be, theoretically, 24×21 or 504 volts peak. Inasmuch as only 250 volts are applied to the plate, it could not develop 504 volts peak signal. Moveover, this signal would produce sufficient bias to reduce the gain of the tube to 1, and, hence, it would never build up this high.

Studying this information graphically, as in Fig. 18, will enable you to see more clearly a comparison between the high frequency amplifier system with and without AVC. Without AVC the output is proportional to the input. At a signal input of 375 microvolts and a gain of 200,000, there would be .000375×200,000=75 volts output of the RF and IF circuits. For any greater signal input, the volume must be manually decreased. Between these values of 375 microvolts and .5 volt input, continual adjustments must be made for each signal received. With AVC these adjustments are made automatically and the amplifier is never overloaded. All AVC systems work on the same general principle as outlined for Fig. 1.

NOISE LEVEL

In assisting the listener to overcome undesirable background noise, the AVC is very helpful. Arising from natural emission disturbances of both the transmitting and receiving tubes, from atmospheric and man-made electrical disturbances, *there is always some amount of noise in connection with reception.* Ranging from a good many volts in an electrical storm to 5 or 10 microvolts from other sources, this *noise voltage* has no fixed value but does have an overall average. This average should be a winter time average when electrical disturbances in the atmosphere are at a minimum.

It is impractical to consider all possible man-made sources of interference as these vary widely in different localities. Only when such disturbances fall below or equal to the average of all of the others may they be regarded as separate sources.

Here again it is necessary to make assumptions based on practical experience. For this example, a *noise level* of 50 microvolts, a noise strength equal to .00005 volt in the antenna, has been chosen. That is, with noise energy of any kind above 50 microvolts there will be continuous noise at any point on the receiver dial. A study of Fig. 19 will help to clarify this principle. Starting with the receiver dial set to 900 KC, assume a station on this frequency is received which produces a maximum *signal field strength* at the receiver location *of less than* 50 *microvolts.* At 920 KC assume there is another station having a field intensity of only 7 microvolts at the receiver. Both of these signals will be received with the receiver tuned to 900 KC, and the noise from the 900 KC carrier will practically blanket out the signal of 920 KC as the 50 microvolt noise

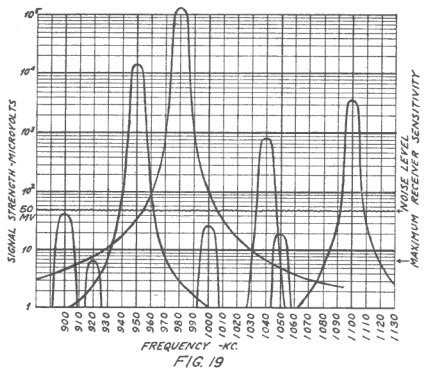


FIG. 19

in this instance is more than 7 times as strong as the wanted signal. Neither AVC nor any other device can help this situation where the noise level is so much higher than the level of the wanted signal. Note in Fig. 19 that slightly above 920 KC, the side-band of the station tuned to 950 KC appears crossing the noise level line at 50 microvolts. When the receiver is tuned to this frequency, the 950 KC signal will be received along with the noise at equal intensity, although the 950 KC signal will be somewhat distorted due to tuning being off resonance. However, as the receiver is tuned further toward 950 KC the signal intensity rapidly increases up to 20 millivolts (20,000 microvolts). If AVC is employed under these conditions the sensitivity of the receiver will be reduced to a point *where the noise cannot be heard.* If AVC is not used the equivalent must be done manually. At 950 KC, the *signal to noise ratio is* $\frac{20{,}000}{50}$ or 400. *Hence, if the receiver is adjusted for average signal volume, the noise cannot be heard.*

Still referring to Fig. 19, if the receiver in question is tuned above 950 KC, the signal strength of the 950 KC signal at the detector drops rapidly to 100 microvolts where it meets the rising signal strength of the stronger 980 KC signal. At this point, the two signals are received simultaneously and interference results. At 980 KC, the signal strength at the antenna is about 200 millivolts, or 2×10^5 microvolts. Again, if no AVC is used, the manual volume control must be turned down considerably to prevent overloading the output tubes. The signal to noise ratio is now 4000 and, of course, the noise is completely gone. If tuning is continued on up to 1020 KC, the sensitivity of the receiver rapidly increases with the AVC voltage reducing. At about 1005 KC noise is again heard because the signal strength of the 980 KC signal falls below the 50 microvolt level Without AVC, the manual volume control must be reduced in order to pick up signals with less sensitivity. With AVC, when tuning across any band of frequencies between stations, the sensitivity of the RF and IF sections will automatically increase in order to pick up less powerful signals.

Since the sensitivity of the receiver varies inversely as the signal strength, it has the effect of making the noise level vary inversely as the signal strength. A powerful signal is always identified by little or no noise when the receiver is AVC controlled.

SIGNAL DELAY METHODS

This lesson has already treated the *time delay* of AVC which has to do with the time required for a

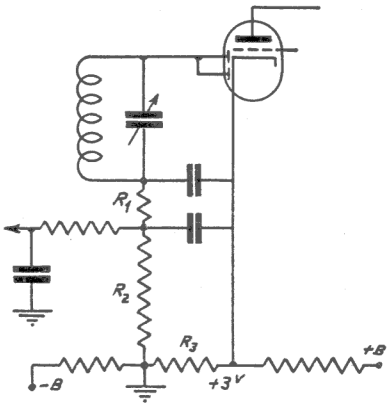


FIG. 20

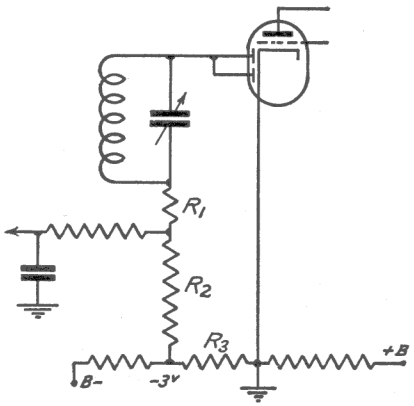


FIG. 21

given signal to build up an AVC voltage for the bias control. It has been shown why this should be rather slow so that it could not operate to eliminate any of the modulation. Obviously, if the AVC voltage were to vary as fast as the modulation varies, voltages would be produced in the bias system which would be inverse to the modulation. This would practically eliminate the modulation.

It will now be shown how the action of the AVC may be *prevented* until a signal of predetermined definite value is received. This is easily accomplished by arranging the second detector circuit so that the *minimum* possible signal strength is definitely fixed. It is apparent that this could be done to eliminate the noise completely in a receiver. An example is shown in Fig. 20, where, if a receiver is designed so that no signal is received below a 50 microvolt noise level no noise at all will be received. Several present-day methods of accomplishing this principle are shown in Figs. 20, 21, 22 and 23.

In Fig. 20 is shown the usual second detector rectifier circuit with AVC connections leading through the filter resistor R_1 and the load resistor R_2 to ground. Between the ground and cathode there is a resistor R_3 which forms a part of the voltage divider, carrying the proper amount of current from the B+ voltage divider to fulfill its function in the operation of the receiver. One of its functions is to keep the cathode at a high (more positive) potential than the *diode plate return* lead so that no rectification can take place until the diode becomes slightly more positive than this amount. The voltage across this resistor R_3

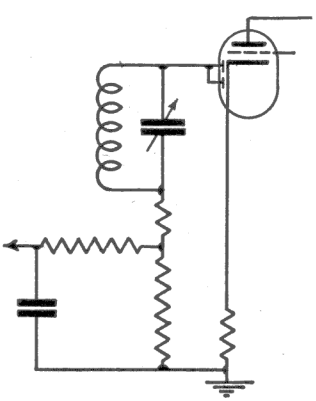


FIG. 22

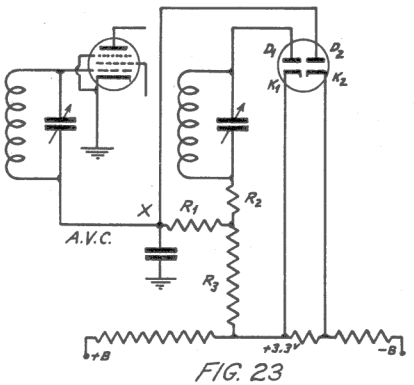


FIG. 23

may be anywhere from 3 to 25 or more volts, depending on the total gain of the receiver, the sensitivity desired at the receiver input and the voltage value of the minimum signal to be picked up.

For example, if the receiver has a gain of 100,000 and the noise level is 30 microvolts, and it is desired to receive no signals below this value, the resistor value of R_3 is so chosen that it will have a 3 volt drop across it. Thus a signal or noise level of 30 microvolts will produce .0003×100,000 or 3 volts across R_2 in Fig. 20. A lower input will produce *less than* 3 *volts* across R_2. The diode plates can never become more positive than the cathode under this condition, and no rectification can take place. For this reason, no signal will be heard. Above an input of 30 microvolts, a signal will be heard *but no noise* provided all of the noise has remained below 30 microvolts. This principle of operation is accomplished because of the fact that the voltage drops across R_2 and R_3 are of opposite polarity. For this example the voltage drop across R_2 must exceed 3 volts before it overcomes the voltage drop of 3 volts across R_3. The net difference between these two voltages is actually the signal voltage value which starts the operation of the diode plates in Fig. 20. For instance, if a 4 volt drop occurs across R_2 this will leave 4−3 or 1 volt to act on the diode plates to start detector action. In this way, all signals reproduced by the receiver will be above the 30 microvolt noise level and will, therefore, be free of noise.

The voltage difference between the diode return and the cathode to form this *signal delay* is entirely arbitrary. For a receiver with a large gain in general, a larger voltage is used for a given input sensitivity. For a low noise level or greater receiver sensitivity, a lower signal delay voltage is used. A delay voltage as high as 25 volts is used in some receivers.

In Fig. 21, the circuit is essentially the same as in Fig. 20 with the cathode at ground potential instead of above ground. Another way of raising the cathode potential above the diode return potential is to employ a regular cathode bias resistor, as in Fig. 22. For this arrangement, the cathode must draw current other than that due to the action of the diode plates because the signal voltage will bring about no bias at all on the diode plates. To make use of this arrangement, the cathode must be a part of a triode or pentode which will carry a fixed DC regardless of the signal. Note that for the circuits of Figs. 20 and 21 to work no cathode current is required to form the delay bias as the voltage is supplied from a separate voltage divider fed from the B+ circuit.

In an endeavor to simplify the entire radio circuit, Fig. 23 was developed. This circuit makes use of a double diode such as the 7B6, 7C6, 6Q7, 6SQ7, 7E7, 7B7, etc. With this arrangement there is no signal delay as both the signal diode cathode, K1, and the diode plate for the signal are grounded.

The AVC voltage is produced as usual at point X with respect to ground. Resistor R1 is as usual a high value, from 300,000 ohms to 1 megohm. At point X the other diode plate is connected, and its cathode, K2, is made to have a potential of −3.3 volts by reason of a voltage divider connection as shown in Fig. 23.

Normally, without any signal, point X will be at ground potential as there is no current flowing in R1, R2 or R3. By the addition of the second diode plate, D2, diode current will flow, as this plate is 3.3 volts more positive than the cathode at the start. The current it draws must flow through R1 and R3 which are selected to produce a 3 volt drop—there being only .3 volt left from the diode plate D2 to its cathode K2. This is easily done by making the sum of R1 and R3 equal to 10 times the DC plate resistance of the diode with .3 volt on its plate. If the latter is 150,000 ohms, the sum of R1 and R3 must be 1,500,000. This may be composed of R1 as 1 megohm and R3 as 500,000 ohms—which, are conventional values. You will recall here that where the current in a series circuit is uniform, the voltage drop across each of its components is proportional to the resistance of that component.

This means that without any signal there will be a bias of 3 volts negative on each tube under control from point X and that no cathode resistor is needed for any of the controlled tubes for the purpose of minimum bias. In addition to this, the receiver will bring in any signal producing less than 3 volts peak at D1 without being affected at all by the AVC. The AVC cannot come into operation until the voltage at D1 overcomes that present at X.

Assuming, as before, that the receiving system has a gain of 200,000, a signal of 15 microvolts is the *threshhold* signal, so called because it is the critical value above which the AVC comes into action and below which the AVC is inoperative. If the noise level happens to be lower than this, which is rarely the case, the receiver can pick up as much lower a signal as its design will permit.

Now, if the total gain of the receiver is only 50,000 to the second detector input, the threshold value will be raised to 60 microvolts as $.00006 \times 50{,}000 = 3$ volts. When the signal voltage advances above 3 volts, all values greater than 3 volts add to that already existing at X, thus making the total AVC voltage up to 50 or more volts. For this purpose, a double diode with two separate cathodes must be used.

MULTIPLE SOURCE AVC

In connection with more detailed design there are, of course, many problems of reception which must be taken into consideration when applying AVC to any receiver. One of the outstanding problems was solved through the use of super control type tubes.

Having considered the detector effects of the super control tubes at high input levels, it seems only reasonable that this should be taken into account when AVC is adopted. For example, in a great many receivers it has been found desirable to place more bias on the antenna or input tube than on others so that where the signal is extremely small, the possibility of detection likewise is small, a very high bias may be used without cross modulation. After the signal grows larger through successive stages of amplification, it is desirable to use less bias so that a more nearly straight portion of the Eg-Ip curve may be brought into use. For this purpose, an ordinary voltage divider is used as in Fig. 24. The three resistors, R1, R2 and R3, comprise the AVC divider and total a value of from 500,000 ohms to 1 megohm. Their individual values depend on the amount of AVC to be distributed to each tube. This may vary widely due to various number of stages of RF and IF used and the gain per stage, the total resulting sensitivity desired and the amount of AVC action expected. In many circuits only one additional intermediate voltage tap is used. For Fig. 24, if R1, R2 and R3 are equal in value and the total AVC voltage developed for the top of R1 to ground is 60 volts, the other values will obviously be 40 volts at the top of R2 and 20 volts at the top of R3. The gain of the first tube will be reduced most and the others successively less. Trace the grid return of each tube to the voltage divider to determine how the AVC voltage is distributed.

In Fig. 24 a different method of developing AVC is introduced. It is called *amplified AVC* because the AVC tube is supplied from an auxiliary amplifier which is capacity coupled to the last IF stage. In this way, an extremely large AVC voltage may be produced from a small signal, *and the entire system is independent of the second detector.* With a signal voltage of only 2 volts on the last IF grid, 60 to 75 volts may be developed for AVC while a power or diode detector may be used for signal rectification at only 2 volts. This has obvious advantages. Note, too, that the amplified AVC input circuit is untuned and hence will re-

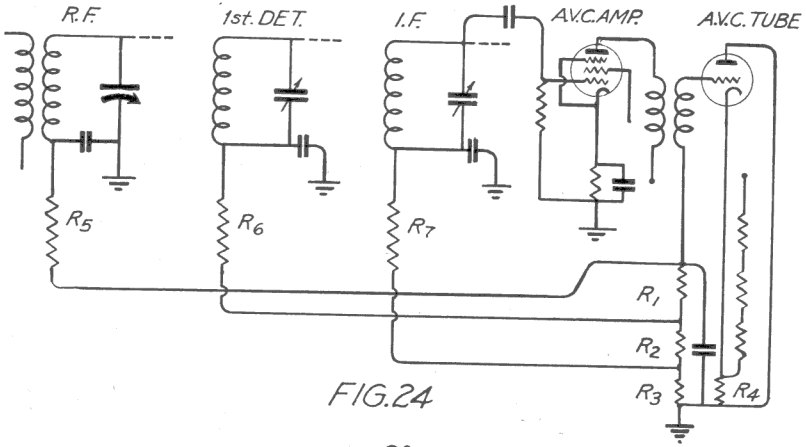


FIG. 24

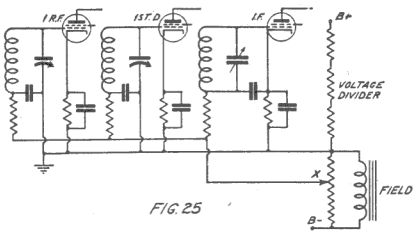


FIG. 25

spond to a much broader band of frequencies than would the second detector. In this way, the AVC will be in control somewhat off resonance. This tends to make tuning more critical or more accurate. It makes the apparent space on the receiver dial for one station somewhat narrower without sacrificing anything in the way of fidelity.

SEPARATE AVC TUBE

AVC was introduced with the separate tube idea, and after winning its place as a worthwhile part of a receiving circuit, tubes and circuits were developed to take advantage of its possibilities. The separate tube method is interesting and worth studying because AVC may be added to existing receivers most easily by this method.

Rather than the actual signal energy being used for developing the AVC, it is used with the separate tube only to control the amount of voltage used from the power supply of the receiver. More or less AVC voltage is made available by more or less signal, as usual.

Refer to Fig. 25. It is obvious from this circuit how voltage from the negative end of the power supply might be used for manual volume control. By sliding the potentiometer moving element X toward ground, the bias on the tubes is reduced and if the moving element is moved in the other direction the bias on the tubes may be increased to 60 volts negative if desired. Here again use is made of the principle that, in any series circuit, the voltage at any point in that circuit is proportional to the resistance at that point.

Your attention is directed to the point X between two resistors, one of which is variable and the other of which is fixed, as in Fig. 26. By varying R2, the voltage at X may be varied because the resistance ratio $\frac{R1}{R2}$ is being varied. For example, if there are 60 volts from ground to B negative as shown, and R1=250,000 ohms, the voltage of X, with respect to ground, will depend on the setting of R2. Several values of R2 with corresponding values of voltage, V1, are given in the accompanying table. From the rule you will immediately see that V1 is part of the total voltage V2 and R1 is a part of the total resistance R1=R2. It is possible, therefore, to write the following equation from the facts as stated.

$$\frac{V1}{V2} = \frac{R1}{R1+R2}$$

Where:

V2 = 60 volts

R1 = 250,000 ohms

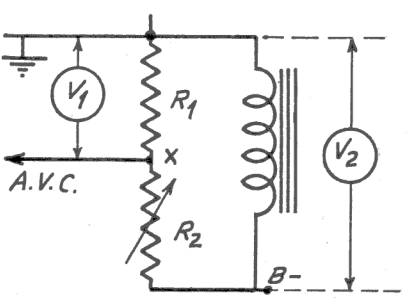


FIG. 26

Since it is desired to solve for V1, simply transfer V2 to the right, obtaining—

$$V1 = \frac{V2 \times R1}{R1 + R2}$$

To tabulate values of V1 which will result when R2 is varied, numerically—

$$V1 = \frac{60 \times 250{,}000}{250{,}000 + R2}$$

$$V1 = \frac{15{,}000{,}000}{250{,}000 + R2}$$

Where:

R2=	50,000 ohms	V1=50	volts
	=100,000 "	=48.2	"
	=250,000 "	=30	"
	=500,000 "	=20	"
	=1 megohm	=12	"
	=2 megohms	= 6.66	"
	=3 "	= 2.855	"

On investigating the resistance requirements of R2, you will find that the plate current of a tube can assume values of resistance ranging from 50,000 ohms to 5 megohms with but a small grid change. It is possible, therefore, to replace R2 with the plate circuit of a tube, as in Fig. 27. Its cathode uses a resistor R3 which normally biases it almost to plate current cut-off. It is a detector or sharp cut-off type tube. Under these conditions, its DC plate resistance is 5 megohms, or greater,

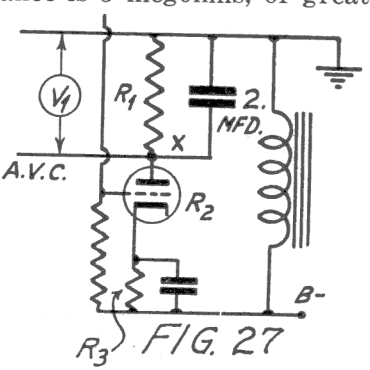


FIG. 27

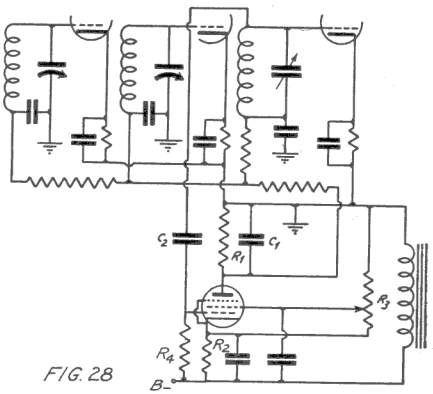


FIG. 28

making V1, or the drop across R1, only 2.855 volts or less.

The slightest signal from the RF or IF of the receiver proper will increase the plate current of this tube greatly because the grid will swing in the positive direction every half cycle. The DC plate resistance of the tube thus drops to 500,000 ohms. Then from the table, point X, now connected to the plate of the tube, will drop from −2.855 volts to −20 volts below ground potential. Notice that the more signal that is fed to the con trol grid, the more bias is placed on all controlled tubes and, hence, AVC is acquired. A complete circuit of this type of AVC is shown in Fig. 28. All of the essential details of a properly functioning circuit are included. C1 is a large (2 mfd.) by-pass condenser to filter out any variations of plate voltage which would result from the grid variations. R3 serves two functions—(1) to act as a divider to draw current through the cathode resistor to insure practically a constant bias regardless of the current drawn by the AVC tube and (2) to provide variable screen voltage to adjust the effectiveness of the AVC action. It is much

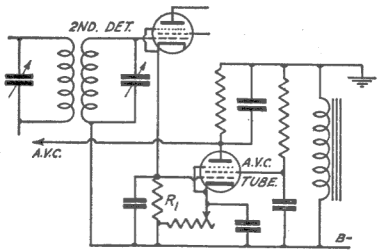


FIG. 29

more effective with high screen voltage than with low. Obviously, this circuit is more flexible in operation than the others you have studied, but this fine adjustment of circuit operation is not considered necessary in present-day design.

The grid of the AVC tube is fed from the plate of the first IF or the grid of the last IF or first detector through a small coupling condenser C2 (.0005 to .0001 mfd.) The AVC control grid circuit is completed to B negative with a .5 megohm to 2 megohm resistor, R4. In this respect the AVC tube operates very much like a power detector with all IF and audio filtered out of its plate circuit. Triodes, tetrodes and pentodes were used for this type of operation regularly. Occasionally the AVC tube grid is fed by the bias voltage drop across the second detector cathode resistor R1, as in Fig. 29. Any signal, when detected, will increase the plate current of a bias type detector, and, in so doing, in this circuit, will make the AVC grid advance in the positive direction. Otherwise the circuit of Fig. 29 is similar to others which have been previously described.

The less popular *full-wave diode detector AVC system* is shown in two forms in Figs. 30 and 31. In these, as in half-wave systems, the

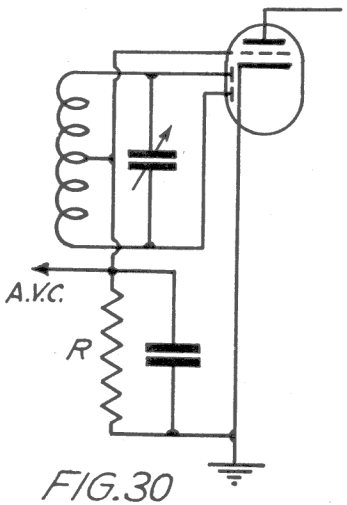


FIG. 30

AVC voltage is developed across a diode load resistor R, and the AVC voltage is applied to the AVC feed line as usual. Note in Fig. 31 the grid (AF amplifier) of the combination tube is entirely isolated from the diode circuit. This is accomplished by using a separate coupling condenser C_1 and grid load resistance R1, for the AF amplifier within the tube envelope.

Since there are two diodes in all of the diode tubes, it is often common practice to use one diode for detection and the other for AVC. Certain salient advantages result. By using only one diode for detection, the load placed on the tuned circuit from which it is fed is lower than if two are used. Moreover, loads can be selected more exactly for each function instead of using a common load for the two functions of providing DC for the AVC and AF for the rest of the system. Generally, the diodes are capacity coupled (C1 and C2) for this type of operation, as in Fig. 32.

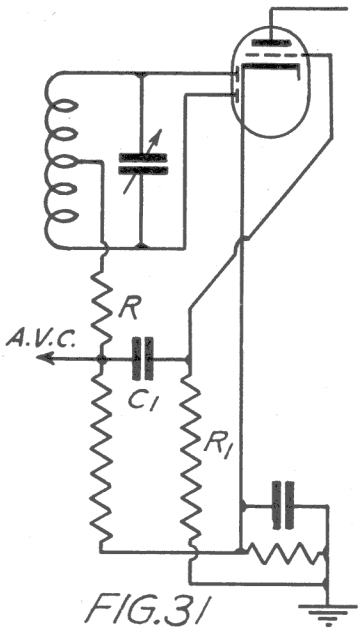


FIG. 31

Q AVC CIRCUITS

A general name applied to one class of circuit for automatically cutting off signals at certain places on the dial or for certain purposes is *Q circuits*. Some of these are called *Quiet circuits Muter circuits, QAVC circuits* and *inter-carrier noise suppressor circuits* and still other names where a special function is combined with AVC.

The practical use of AVC created a demand for Q circuits because of the nature of operation of the receiver when provided with AVC. With any form of manual volume control, the receiver sensitivity remains substantially constant for any one setting of the manual volume control. But with AVC, this is not true as the *sensitivity of the receiver radically changes* when tuning from one station to another. If the manual volume control of the receiver is adjusted for fair room volume in tuning across the broadcast band, between stations noise will be received due to man-made interference, atmospheric interference, noise level disturbances and much other undesirable noise of this kind. It would be very desirable *to cut the signal out of the audio system and speaker* entirely until resonance is reached with the desired signal.

The first means of accomplishing this was to use a manually operated push-button which controlled some vital circuit of the audio system. In some cases, one or more grids were shorted to ground or the speaker voice coil was shorted or opened by a push-button switch. The pushbutton was simply held depressed until the station was tuned in. This being a great inconvenience, automatic means were sought to solve the problem.

Although a great number of methods have been developed, the method meeting with the most popular acceptance will be described. The silencing button method is shown in two applications in Figs. 33 and 34.

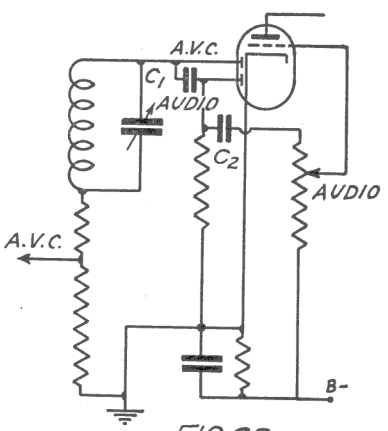


FIG. 32

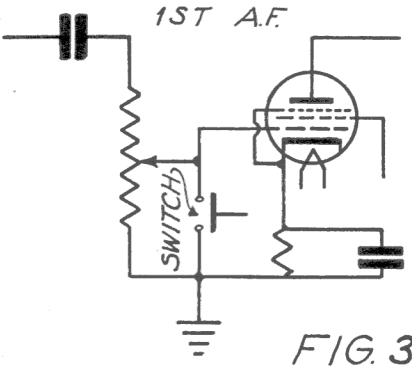


FIG. 33

In Fig. 35 is shown a complete automatic Q circuit employing a pentode tube of the sharp cut-off type, such as the 6J7 and 77 tubes. You are familiar with everything up to the audio grid except its grid return connection. The plate circuit of the Q tube with the audio grid resistor R1 forms a potentiometer across a section of a voltage divider consisting of R2-R3-R4-R5. R3 is the regular bias resistor for the first audio tube and, when no current flows through the Q tube and R1, the voltage at X is the same value as that at Y. *In this way the tubes operate normally from the output of the second detector.* Point Y is about 100 volts positive but this makes no difference in the operation of the 1st AF tube due to the way its grid return is connected to R3.

Now when the control grid of the Q tube becomes *less negative*—enough so that the tube's plate circuit *may draw current*, the voltage at X reduces and remains at a value dependent upon the ratio of R1 to the internal DC resistance of the Q tube. Obviously, if point X is now only 10 volts positive while Y is 100 volts positive, the control grid of the first AF *will have a negative bias* 100—10 *or* 90 *volts* on it *and no signal can be amplified* because with this high bias the tube is completely inoperative.

The rectifier action of the second detector diode builds up a negative voltage across the resistors R6-R7-R8-R9 in proportion to their values and a small portion of this negative voltage is applied to the Q tube grid by the adjustment of R7. As the signal strength increases, the Q tube becomes biased to cut-off and the *audio tube operates normally.* When there is no signal, there is no bias on the Q tube, and its current brings about a complete cut-off of audio signals.

Thus, in tuning a receiver crcuit equipped in this way, only signals are received *and between stations the receiver is completely silent.*

In Fig. 36 another method is used in which the screen grid voltage on the first audio amplifier is used to control the signal. A pentode is likewise used for the Q tube because of its sharp cut-off characteristics with a small control grid voltage. Here the screen grid is supplied through R1 from B+ and the Q tube is in shunt with the screen grid to ground circuit. Resistor R1 and the Q tube may be regarded as the usual series automatic potentiometer, for when the Q tube draws a large

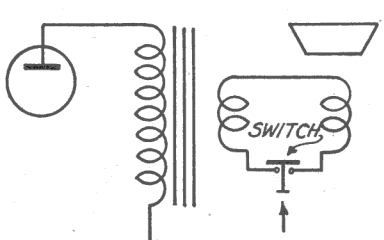


FIG. 34

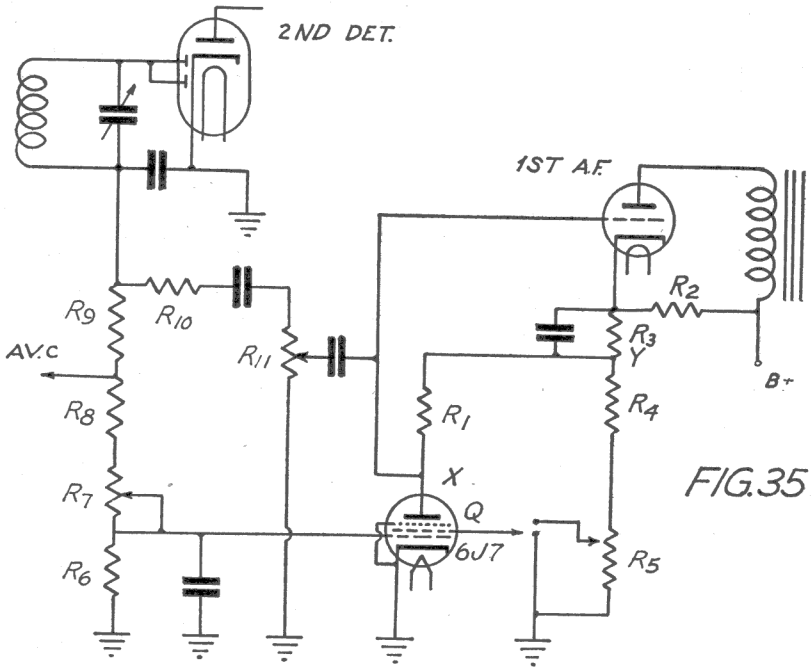


FIG. 35

current, the voltage at X is low, and when it draws no current, the voltage at X is maximum. Connected to the AVC voltage source the control grid of the Q tube makes it draw a large plate current for no signal and no current for an appreciative signal. The screen grid of the Q tube is attached to a variable control *so that its point of cut-off or point of threshhold operation may be varied.* Two adjustments are provided for the circuit in Fig. 35 for this purpose—one at R7 and the other at R5.

The suppressor grid of a Q tube may be controlled in the same way that the control grid is controlled in Fig. 35. In Fig. 37 a circuit making use of suppressor grid control is shown. The operation of Fig. 37 should be obvious after the study of Fig. 35 as the principle of operation is identical except different grids are employed for control.

AUTOMOTIVE AND BATTERY AVC CIRCUITS

By far the greatest necessity for AVC is in the automobile radio set. Because of large changes in signal ratios (due to the auto traveling) more than for the facility of tuning, AVC assumes its greatest advantage in auto receiver design. Because of the shielding effect of buildings, hills, telephone lines,

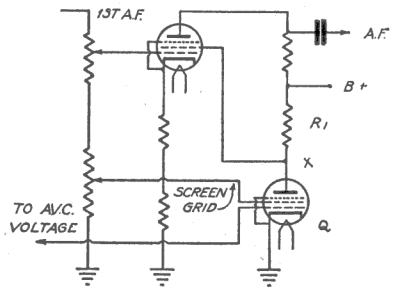
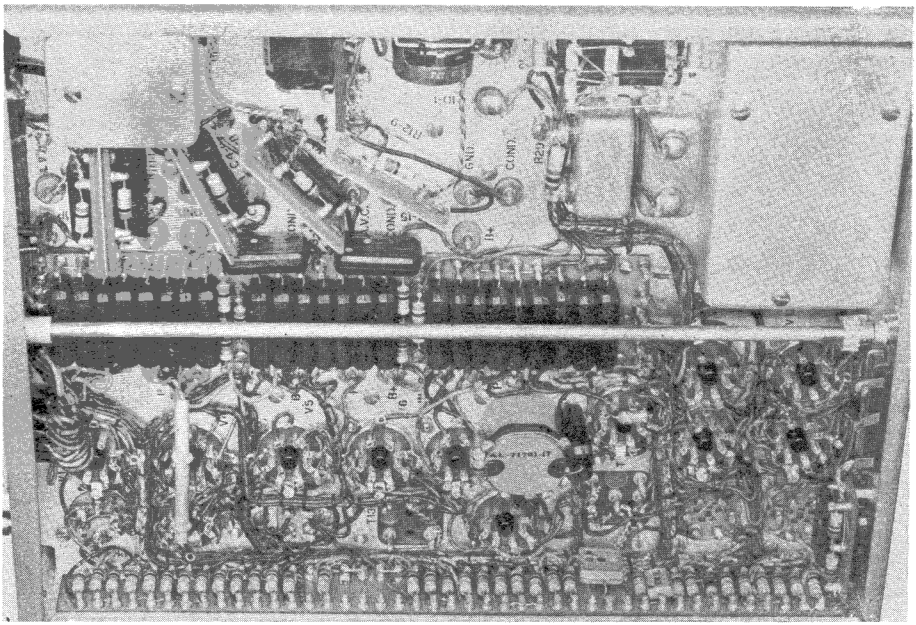


FIG. 36



The above view shows the underside of a Bendix radio compass as used in aircraft. It is an outstanding example of neat and careful arrangement of parts. It employs an AVC system which works on the same principles as those described in this lesson.

bridge structure and countless other things, the signal intensity of a radio wave varies considerably from one point to another. In fact, the signal strength may vary as much as 1,000,000 to 1. Almost invariably as you drive under a large, low, steel bridge, an underpass, a valley or tunnel, the signal strength will be so low that the receiver may be inoperative. The sensitivity of the receiver will, accordingly, build up to maximum, and, if not thoroughly suppressed ignition interference will be received. On emerging at the other end of the obstruction, the station carrier will reduce the sensitivity of the receiver again, blocking out the interference and bringing in the signal strong. This process is very much like tuning from one station to another. As you drive along the road, the sensitivity of the receiver will vary inversely as the field strength of the station to which the set is tuned, presenting the illusion of practically constant volume. You will know where the signal strength is lowest as the receiver sensitivity will dip down in field strength until it reaches the noise level.

All automotive radio circuits and those for other mobile use employ AVC, and these are ordinarily identical to AC operated types.

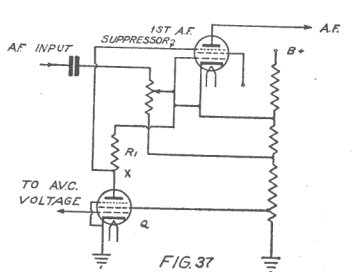


FIG. 37

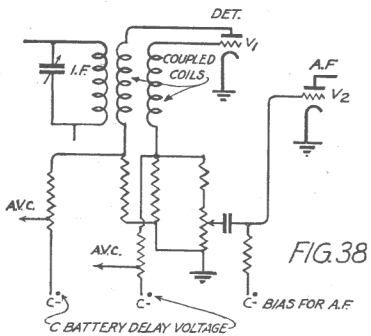


FIG. 38

The battery receiver, however, requires a little alteration due to some of the requirements of such receivers. A typical battery operated type of AVC is shown in Fig. 38. This will easily be recognized as a simple adaptation of the principles which you have already studied. Signal delay voltages are applied externally by means of C batteries as indicated. Two AVC sources are shown, but as many more may be obtained by using additional voltage dividers. Note that both the plate and grid (acting as diodes) of a filament triode tube V1 are used for AVC— accommodating the signal as well. Remember that there are almost countless adaptations of these basic ideas which you can easily pick out and analyze from the principles set forth in this lesson. In fact, there are no two systems exactly alike in every detail— manufacturers vary their circuits considerably as you will learn as you get more experience.

These questions are designed to test your knowledge of this lesson. Read them over first to see if you can answer them. If you feel confident that you can, then write out your answers, numbering them to correspond to the questions. If you are not confident that you can answer the questions, re-study the lesson one or more times before writing out your answers. Be sure to answer every question, for if you fail to answer a question, it will reduce your grade on this lesson. When all questions have been answered, mail them to us for grading.

QUESTIONS

No. 1. What are the two main purposes of diode rectification as employed in the modern superheterodyne?

No. 2. In what way does the AVC voltage differ from the signal voltage actually applied to the first audio grid?

No. 3. What would happen to reception if the AVC filter resistor and condenser such as Ra and C3 in Fig. 14 were extremely small in value?

No. 4. Is the AVC voltage proportional to the audio signal or to the carrier?

No. 5. Is the sensitivity of a receiver highest when tuned to resonance or is it highest off resonance when AVC is used?

No. 6. Referring to the curves in Fig. 18, what would the total gain of the receiver be with AVC and an input of 70,000 microvolts (locate the 70,000 line on the graph between 10^4 and 10^5)?

No. 7. If the noise level must not be more than 10% of the signal intensity for satisfactory reception, how many of the signals in Fig. 19 can be received satisfactorily?

No. 8. What is meant by an AVC voltage delay circuit?

No. 9. Is the same value of AVC voltage always used to bias each of the controlled tubes?

No. 10. Is it essential to have a diode detector in order to employ AVC in a receiver?